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Short Report

Reliability of inter-anterior superior iliac spinous distance as compared to foot length for stature estimation in South Indians

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ABSTRACT

Estimation of stature from isolated body parts is especially important to forensic scientists and anthropologists. The aims of this study were, to evaluate the accuracy of inter-anterior superior iliac spinous distance in determining stature of an individual as compared to foot length, and to note sex differences in the above mentioned parameters.

One hundred normal healthy adult subjects from South India consisting of 50 males and 50 females were studied. The height, interspinous distance, and foot length of the subjects were measured. The mean and standard deviation of the height, interspinous distance, foot length and proportions of interspinous distance and foot length to height were calculated and significance testing done for sex differences. The correlation between stature and interspinous distance and stature and foot length was estimated, and linear regression equations for stature estimation were calculated.

The height, interspinous distance and foot length were significantly greater in males. The proportion of interspinous distance to stature was significantly greater in females. Foot length showed a stronger positive correlation with stature compared to interspinous distance. When the sexes were considered separately the accuracy of stature estimation from interspinous distance increased greatly.

Though interspinous distance is not as reliable as foot length in stature estimation, it could provide valuable data regarding the stature when isolated pelvises are available.

1. Introduction

Estimation of stature from isolated body parts is especially important to forensic scientists and anthropologists. The correlation of stature with measurements of the face, upper limb, vertebral column, and lower limb has been attempted.[1] Numerous studies have shown that foot length (FL) has a strong positive correlation with the stature.[1–5] Bare footprints recovered from the scene of a crime are more commonly encountered in India and serve as valuable evidence in the identification of an individual.[3] The accuracy of stature estimation from foot length has improved with the use of regression equations in place of multiplication factors that were used previously. Previous studies have shown that racial and sex differences exist in the foot length relative to stature.[3,4]

A large study conducted in Thailand showed that the FL could be used to accurately determine the distance between the two anterior superior iliac spines (interspinous distance – ISD).[2] In males, the distance from the right heel to the tip of the fourth toe closely approximated the ISD. In females however, the ISD was nearly equal to the distance from the right heel to the tip of the big toe. In the same study it was found that FL and ISD correlated well with height.[2] There is a paucity of data about the correlation of the ISD with stature in other populations. Thus, the present study was undertaken. The aims of this study were, to evaluate the accuracy of ISD in determining the stature of an individual as compared to the FL, and to note sex differences if any in the above mentioned parameters.

2. Materials and methods

The subjects for the study were normal healthy adult volunteers and college students from South India. The procedure was

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Fig. 1. Instrument used to measure the foot length.

explained to the subjects who then signed an informed consent form. Ethical clearance for the study was obtained from the Institutional Ethical Review Board (IERB). A total of 100 subjects consisting of 50 males and 50 females were studied. Males and females of the age of 18 years and above were included in the study. The mean age of the subjects was 23 years (range 18–43 years). None of the subjects had any injury or deformity of the body that might have had an influence on the measurements of the pelvis, feet or stature.

The height of the subjects was measured with the subjects barefoot, standing erect, the feet placed together and head oriented in the Frankfurt plane. Measurement of the ISD was performed using sliding callipers with the subjects supine and keeping the pelvis square (Fig. 1). A specially designed measuring instrument as described Waikakul et al.[2] was used to measure the FL (Fig. 2). The instrument consisted of a heel support and a board to which a scale was fixed. The distance from the heel to the tip of either the 1st or 2nd toes, whichever was greater, was considered as the FL. For measurement of the FL, the subjects were seated, with the hip and knee flexed at 90° and the foot placed on the measuring board. Measurements were made only on the right foot. All three measurements i.e. height, ISD and FL were made in centimetres.

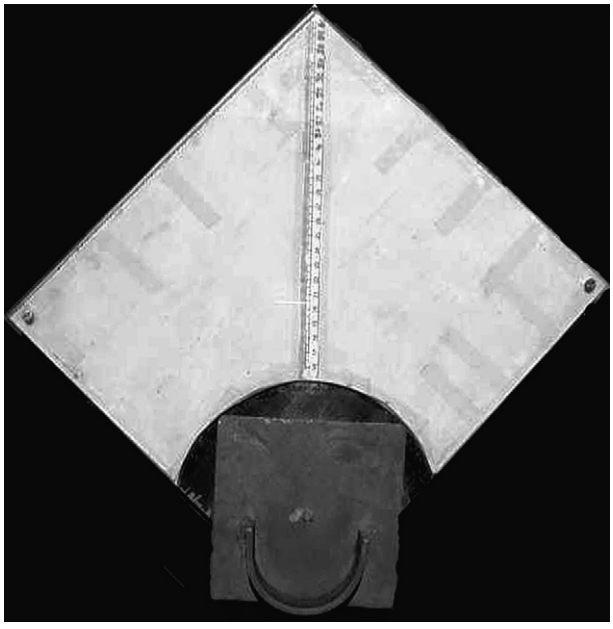

Fig. 2. Measurement of the inter-anterior superior spine distance using sliding callipers.

The mean and standard deviation of the height, ISD, and FL were calculated for all the subjects, as well as for males and females separately. The Mann Whitney U test was used to check for significant sex differences in these three parameters. The proportion of both ISD and FL as a percentage of the height (pISD and pFL respectively) was calculated. The mean, standard deviation and significance testing was done as mentioned above. The correlation between stature and ISD and stature and FL was estimated by Pearson's correlation coefficient. Linear regression equations for stature estimation from ISD and FL were calculated and the errors of estimation were analyzed.

3. Results

The mean and standard deviation of the height, ISD, FL, pISD, and pFL are shown in Table 1. It was evident that the height, ISD and FL were significantly greater in males as compared to females. However, the value of pISD was significantly greater in females. The value of pFL did not show any significant sex differences.

The Pearson's correlation coefficient, linear regression formulae and percentage errors in estimation are shown in Table 2. When ISD and FL were correlated with stature, the FL showed a stronger positive correlation compared to the ISD. The correlation was the greatest for both ISD and FL when all the subjects were considered together. Females showed a higher positive correlation for both ISD and FL as compared to males.

On estimation of the stature across the sexes from the ISD and comparing these values with the actual stature, it was found that in 35 (35%) subjects there was less than 3% error in estimation. However, when sexes were considered separately the accuracy of stature estimation increased greatly. When FL was used for estimation of stature across sexes, 72 (72%) subjects had less than 3% error in estimation. The accuracy of stature estimation increased only marginally when the sexes were considered separately. The mean percentage error in stature estimation of all subjects using ISD and FL was 4.58% and 2.12% respectively.

4. Discussion

The determination of stature from body parts has assumed even greater significance in modern times due to the increased frequency of deaths caused by explosions, air traffic accidents, and other high impact injuries. In addition, reconstruction of living

Table 1
Comparison between stature, ISD, FL and their proportions.

Parameter	Combined (n = 100) Mean ± SD (Range)	Male (n = 50) Mean ± SD (Range)	Female (n = 50) Mean ± SD (Range)	Significance[$]
Stature	164.76 ± 10.03 (141–186)	172.82 ± 5.65 (159–186)	156.7 ± 6.24 (141–170)	<0.0001
ISD	21.84 ± 1.67 (17–26)	22.26 ± 1.24 (19.8–25.3)	21.42 ± 1.93 (17–26)	0.002
pISD	13.27 ± 1.06 (11.48–17.45)	12.86 ± 0.75 (11.48–14.36)	13.68 ± 1.17 (11.75–17.45)	0.0001
FL	24.47 ± 1.6 (20.8–28.9)	25.67 ± 3.62 (23.3–28.9)	23.27 ± 1.04 (20.8–26.4)	<0.0001
pFL	14.88 ± 0.43 (13.97–16)	14.9 ± 0.47 (14.06–15.97)	14.85 ± 0.40 (13.97–16)	0.26

ISD – interspinous distance; pISD – ISD as a percentage of stature; FL – foot length; pFL – FL as a percentage of stature; n – number of subjects; $ – significance testing between males and females.

Table 2
Pearson's correlation coefficient, linear regression formulae and percentage of error for stature estimation.

	Parameter		Combined (n = 100)	Male (n = 50)	Female (n = 50)
Pearson's correlation (r, r^2 values)	ISD		0.38, 0.14	0.24, 0.06	0.35, 0.12
	FL		0.90, 0.81	0.68, 0.47	0.81, 0.65
Linear regression	ISD		S = 2.265ISD + 115.304	S = 1.074ISD + 148.909	S = 1.125ISD + 132.593
	FL		S = 5.629FL + 27.02	S = 3.608FL + 80.208	S = 4.794FL + 45.132
Percentage error of estimation of stature	ISD	<3%	35 (35%)	33 (66%)	31 (62%)
		>3%	65 (65%)	17 (34%)	19 (38%)
	FL	<3%	72 (72%)	41 (82%)	40 (80%)
		>3%	28 (28%)	9 (18%)	10 (20%)

n – number of subjects; S – stature; ISD – interspinous distance; FL – foot length.

stature from skeletal remains is useful to the forensic anthropologist. The FL is known to be an accurate indicator of stature.[1–5] A strong positive correlation between the ISD, FL and stature was noted in a study conducted in 600 volunteers between the ages of 10–70 years in Thailand.[2] This correlation was utilized by the authors[2] to accurately determine the ISD from the FL. The data was then successfully used for the external fixation, reduction and stabilization of unstable fractures of the pelvis in 36 patients.[2] To our knowledge, no other study has been conducted to determine the usefulness of ISD in the estimation of stature and its accuracy in doing so vis-a-vis the FL.

In the present study, the mean ISD in males was significantly greater than in females. However, the mean pISD was significantly greater in females, indicating that for a particular height the ISD was greater in females (Table 1). This is in agreement with the study conducted in Thailand.[2] The calculation of stature from the ISD using linear regression formulae thus showed a greatly increased accuracy when the sex was considered (Table 2). The identification of sex from the pelvis has an accuracy of around 95%.[6,7] Thus, using the sex specific regression formulae, stature can be estimated from the ISD to within 3% of the actual value in 66% and 62% of males and females respectively (Table 2).

The mean FL was found to be significantly greater in males as compared to females. Previous studies have shown a mean pFL ranging from 14.9 to 18.1.[3] The values of the mean pFL in the present study correspond to the lower limit of the range mentioned above. The mean pFL, though greater in males was not significantly so. The greater mean pFL in males is in agreement with many other studies conducted in various populations.[8] This may reflect a history of intersexual selection favouring reductions in female FL.[8]

When both sexes are considered together, previous studies have shown a high correlation between FL and stature ranging from 0.87 to 0.877.[3–5] These values are similar to the value obtained in the present study (Table 2). An interesting finding is the higher correlation coefficient between FL and stature in females as compared males (Table 2). This is similar to a study conducted in Turkey where the correlation coefficients were 0.741 and 0.678 in females and males respectively.[4] However another study conducted in Mauritius showed an opposite trend with higher values in males (0.720) as compared to females (0.608).[5] There are numerous influences on the anatomical structure of the foot such as genetic factors, climate, physical activity, nutritional status and type of footwear.[4] Thus, it is difficult to precisely determine the reasons for the differences noted above in the correlation coefficients.

The correlation between FL and stature was higher as compared to the ISD and stature, across sexes as well as when males and females were considered separately (Table 2). This study is at variance to the study conducted in Thailand where both FL and ISD showed comparable high positive correlations with the stature.[2] This discrepancy could be due to differences in race and age distribution in the populations studied. In the Thai study, measurements were made on 420 male and 180 female volunteers. A 100 volunteers (70 males and 30 females) each were recruited in the age range of 10–20, 20–30, 30–40, 40–50, 50–60 and 60–70 years. In the present study there were no volunteers less than 18 years of age or more than 43 years of age. Most of the volunteers were less than 30 years of age.

The stature could be estimated with greater accuracy using FL as compared to ISD. This difference in accuracy was most evident when all the subjects were considered. However, when the sexes were considered separately, the accuracy of the ISD approached that of the FL in determining the stature. Though ISD is not as reliable as FL in stature estimation, it could provide valuable data regarding the stature when only isolated pelvises are available. Accuracy of stature estimation from ISD is greatly increased when the sex is known. As sexing of the pelvis can be done with a fair degree of certainty, the estimation of stature from ISD will prove to be valuable.

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Conflicts of interest

There are no conflicts of interest.

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Ethical approval

Ethical Approval for the study was given by the Institutional Ethical Review Board (IERB). The Judgement's reference number was IERB/1/328/07.

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